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Dated 21 March 2003

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P01/7700 0.00-0131084.6

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Request for grant of a patent

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1.	Your reference	PJA/C089042PGB **0131084.6**
2.	Patent application number *(The Patent Office will fill in this part)*	29 DEC 2001
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	HEAT TRACE LIMITED TRACER HOUSE CROMWELL ROAD BREDBURY STOCKPORT CHESHIRE SK6 2RF
	Patents ADP number *(if you know it)*	6595714001
	If the applicant is a corporate body, give the country/state of its incorporation	UNITED KINGDOM
4.	Title of the invention	HEATING CABLE
5.	Name of your agent *(if you have one)*	Marks & Clerk
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Sussex House 83-85 Mosley Street Manchester M2 3LG
	Patents ADP number *(if you know it)*	18004

		Country	Priority application number *(if you know it)*	Date of filing *(day/month/year)*
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number			

		Number of earlier application	Date of filing *(day/month/year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application		

8.	Is a statement of Inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES

HEATING CABLE

The present invention relates to a heating cable and a pipeline incorporating the heating cable such that heat generated in the cable is transferred to the pipeline.

It is well known to use heating cables to maintain the temperature of process plant such as pipelines at a required process temperature. Heating cables used in such applications come in many forms including simple copper wire assemblies, assemblies incorporating positive temperature co-efficient compounds, and assemblies incorporating wire heating elements bridging power supply conductors extending along the length of the cables. If the process plant is readily accessible, for example a pipeline within a refinery, the pipeline is generally installed in position and after, installation of the pipeline, the heating cable and a thermally insulating jacket are mounted on the pipeline. In some applications however, for example sub-sea oil pipelines, the pipeline is not readily accessible and therefore it is necessary to deploy the pipeline after heating cables and insulation have been installed on the pipeline.

Typically, pipelines incorporating heating cables which are used in sub-sea oil installations comprise heating cables in the form of a solid body of for example copper which is flattened into a tape-like structure with a width of the order of 15mm and a thickness of the order of 1mm. The solid body of copper is enclosed in an electrically insulating sheath, and secured in contact with the pipeline to be heated. The heating cable may be secured in position by for example inserting the cable in a channel an open side of which faces the pipeline, or by using fastening straps wrapped around the outside of the pipeline and the heating cable. The pipeline assembly is then encased in a thermally insulating material such that most of the heat generated by the heating cable is transferred to the pipeline and its contents.

To assist in the deployment of such pipelines incorporating heating cables, it is known to coil the pipeline on large reels from which the pipeline can be deployed. The curvature of such coils is relatively large (typically of the order of 10 metres). The pipeline itself can be readily coiled given a sufficiently large coil diameter, and the heating cable can also be relatively easily coiled so long as the curvature of the heating element is such that the heating element is bent about an axis parallel to the tape width. It is difficult however to coil a pipeline so as to ensure that the heating

cable is always bent in such a manner and as a result certain sections of the pipeline will be coiled in a direction which means that the heating cable is bent about an axis which is perpendicular to the plane defined by the tape. Bending a cable in such a direction applies substantial stresses to the cable which can result in displacement of the cable from its intended position or in the worst case breakage of the heating cable.

Although problems of cable stressing resulting from pipeline bending are particularly severe in the case of pipelines deployed from a coil, even in the case of pipelines that are not coiled before deployment problems can still arise as a result of bending due to the pipeline following the contour of the surface on which it is laid. In practice, few pipelines are straight after deployment, and even a relatively large radius of curvature in a bend of a pipeline can cause problems.

A further problem encountered with the known pipelines incorporating solid copper heating elements is that when heated the heating element will inevitably expand. In a pipeline installation for example 1 kilometre or more in length such expansion forces the heating cable to deform so that its shape in the direction of its length undulates, moving the heating cable away from the pipeline to be heated. Such expansion can also result in damage to the cable and in the worst case cable failure. Given that once such pipelines have been installed repair of the heating cable is generally not a practical possibility, heating cable failure can result in very substantial economic consequences.

It is an object of the present invention to obviate of mitigate the problems outlined above.

According to the present invention, there is provided a heating cable formed from a plurality of deformable elements and comprising deformable electrical heating elements which extend between ends of the cable, the elements forming the cable being disposed such that the cable is of flattened tape-like form, substantially all of the elements are substantially longer than the cable, and each element comprises a series of sections with adjacent sections being connected in series and each section extending in a direction with a substantial component parallel to the length of the cable and a substantial component perpendicular to the length of the cable.

The invention also provides a pipeline incorporating a heating cable as defined in the preceding paragraph.

The term "flattened tape-like form" is intended to indicate a cable cross-sectional shape with a width substantially greater than its thickness.

Given that each individual heating element does not simply extend in the direction of the length of the cable, the deformability of the individual heating elements makes it easier for the cable to accommodate bending resulting from for example coiling of the pipeline before deployment. Furthermore, thermally induced expansion and contraction of the individual heating elements can be accommodated by relatively small deformations of the individual elements given that each individual heating element has portions which are inclined to the length of the cable.

The heating cable could include one or more additional elements extending parallel to the cable length to provide for example mechanical strength, providing the or each additional element is arranged so as to be readily bent in any direction. For example, a single additional element in the form of steel wire could be arranged along one side of the cable.

Preferably the cable is woven such that each heating element follows a path which extends back and forth across the width of the cable with adjacent sections of the element extending in opposite directions across the cable. Each section of the element may extend at an angle of from 10° to 80° to the length of the cable, preferably at an angle of from 30° to 60°, and most preferably at an angle of 45°.

Individual elements may have a thickness in the range of 0.05 to 1mm diameter if formed of for example a tin/nickel coated copper wire strand, or a thickness of from 0.05 to 1.5mm if formed of a tin/nickel coated copper or aluminium foil. The uninsulated heating elements may form a structure having a thickness of for example between 1mm and 5mm and a width of for example from 20 to 50mm. The cable may be encased in an insulating sheath, for example an inner sheath of for example 5 to 12.5mm overall thickness (from the top of the tape-like cable to the bottom). An additional outer sheath may be provided having a thickness of for example 1mm. The inner sheath may be of silicon rubber, PVC or TPE and the outer sheath may be formed of similar materials.

Preferably, when the inner sheath is applied a vacuum is applied to the space between the sheath and the individual elements so as to ensure intimate contact

between the sheath and the individual elements, thereby enhancing heat transfer efficiency.

An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic end view of a pipeline incorporating a heating cable in accordance with the present invention;

Figure 2 is an enlarged view of one heating cable shown in the structure of figure 1; and

Figure 3 is a detailed cut away view of the heating cable of figure 3.

Referring to figure 1, a pipeline 1 which may be manufactured of steel is encased in a thermally insulating sheath 2. Twelve heating cables 3 extend along the length of the pipeline 1, the heating cables being sandwiched between the outer surface of the pipeline 1 and the insulating sheath 2.

Referring to figure 2 each heating cable 3 comprises an electrically conductive tape 4 enclosed within an electrically insulating sheath 5. As shown in figure 2, each heating cable 3 is received within a cavity defined between the pipeline 1 and the insulating sheath 2. The heating cable 3 may be installed in a channel (not shown) formed on the pipeline 1 before or after the application of the insulating sheath 2, the cable being pulled into that channel in a subsequent manufacturing step. Alternatively, the heating cable 3 may be positioned adjacent the pipeline 1, held in place by straps or other fastenings (not shown), and thereafter encased in the insulating sheath 2.

Structures of the general type described in figures 1 and 2 are known. Figure 3 illustrates the detail of a heating cable which may be incorporated in a pipeline and which is in accordance with the present invention.

Referring to figure 3, the illustrated heating cable 3 comprises an electrically conductive tape 6 woven from individual strands of heating element such that each of the elements follows a path along the length of the tape which extends back and forth across the width of the tape. Adjacent sections of each heating element are inclined to the length of the tape at an angle of between 30° to 60°, the optimum angle being 45°. The tape 6 is encased in an inner insulating sheath 7 which in turn is encased in an outer insulating sheath 8.

Individual heating elements in the tape 6 may be manufactured from for example a tin/nickel coated copper wire or a copper or aluminium foil. The wire may have a diameter of for example 0.05 to 1mm, or in the case of an aluminium or other foil, a thickness of 0.05 to 1.5mm. The width of the tape 6 may be of the order of 20 to 50mm and the thickness of the tape 6 may be for example 1.0mm.

The inner sheath 7 may be manufactured from silicone rubber, PVC or TPE and generally will have a minimum thickness of 0.1mm in the case of silicone rubber or 0.2mm in the case of PVC or TPE. The outer sheath 8 may also be manufactured from silicone rubber of PVC or TPE, and will have a minimum thickness of 0.1mm in both cases. Typically the overall thickness of the inner sheath 7 will be from 5 to 12.5mm and the overall thickness of the outer sheath 8 will be from 7 to 14.5mm. The width of the inner sheath 7 will typically be from 20 to 50mm and the width of the outer sheath will typically be from 22 to 52mm.

The optimum wire or foil angle to achieve the desired flexibility when the cable is bent will be 45°. The preferred wire strand diameter will be 0.15mm in the case of tin/nickel coated copper wire and the optimum foil thickness in the case of aluminium will be 0.4mm. This will minimise the size of the spaces between adjacent strands of the heating elements and maximise the cross sectional area of the elements whilst maintaining appropriate element strength.

Compared to a solid tape formed from for example a flattened length of copper, with the arrangement shown in figure 3, the risk of element breakage due to mechanical/thermal stresses is significantly reduced as a result of enhanced flexibility. Any forces acting on an individual element are distributed over the many wire/foil ends. Some wire/foil breakages may occur without seriously affecting the cable performance.

In addition to providing enhanced flexibility, forming a tape from many relatively small wires or foils provides a relatively high surface area to volume ratio which makes the tape more thermally efficient. This in turn lowers the required conductor operating temperature, thereby increasing the life expectancy of the heating cable.

It is important that during the primary sheath extrusion process a vacuum is applied to evacuate any air from the spaces between heating elements in the cable.

This optimises the contact between the conductor and the primary sheath by filling the element interstices, thereby ensuring good thermal transfer between the heating elements and the sheath and hence from the overall assembly to the heated pipeline.

CLAIMS

1. A heating cable formed from a plurality of deformable elements and comprising deformable electrical heating elements which extend between ends of the cable, the elements forming the cable being disposed such that the cable is of flattened tape-like form, substantially all of the elements are substantially longer than the cable, and each element comprises a series of sections with adjacent sections being connected in series and each section extending in a direction with a substantial component parallel to the length of the cable and a substantial component perpendicular to the length of the cable.

2 . A heating cable according to claim 1, wherein the cable is woven from the deformable heating elements.

3. A heating cable according to claim 1 or 2, wherein each heating element follows a path which extends back and forth across the width of the tape such that adjacent sections of the element extend in opposite direction across the tape.

4. A heating cable according to claim 3, wherein the sections of the heating element extend at an angle of from 10° to 80° to the length of the cable.

5. A heating cable according to claim 4, wherein the sections of the heating element extend at an angle of from 30° to 60° to the length of the cable.

6. A heating cable according to claim 5, wherein the sections of the heating element extend at an angle of 45° to the length of the cable.

7. A heating cable according to any preceding claim, wherein the heating elements are formed of wire.

8. A heating cable according to claim 7, wherein the wire has a diameter of from 0.05 to 1mm diameter.

9. A heating cable according to any one of claim 1 to 6, wherein the heating elements are formed of foil.

10. A heating cable according to claim 9, wherein the foil has a thickness of from 0.05 to 1.5mm.

11. A heating cable according to any preceding claim, wherein the deformable elements form a structure having a thickness in the range of 1 to 5mm.

12. A heating cable according to any preceding claim, wherein the cable is encased in a sheath formed in intimate contact with the heating elements to provide good thermal energy transfer to the sheath.

13. A heating cable according to claim 12, wherein the sheath comprises an inner sheath encased in an outer sheath.

14. A pipeline incorporating a heating cable in accordance with any preceding claim, the heating cable extending along the length of and being located adjacent an outer surface of the pipeline.

15. A heating cable substantially as hereinbefore described with reference to the accompanying drawings.

16. A pipeline substantially as hereinbefore described with reference to the accompanying drawings.

ABSTRACT

An elongate heating cable which can be used to heat a pipeline. The heating element is positioned to extend along the length of and is located adjacent an outer surface of the pipeline. The heating cable is formed from a plurality of deformable heating elements which are assembled together by for example weaving such that each heating element comprises a series of sections with adjacent sections being connected in series and each section extending in a direction with a substantial component parallel to the length of the cable and a substantial component perpendicular to the length of the cable.

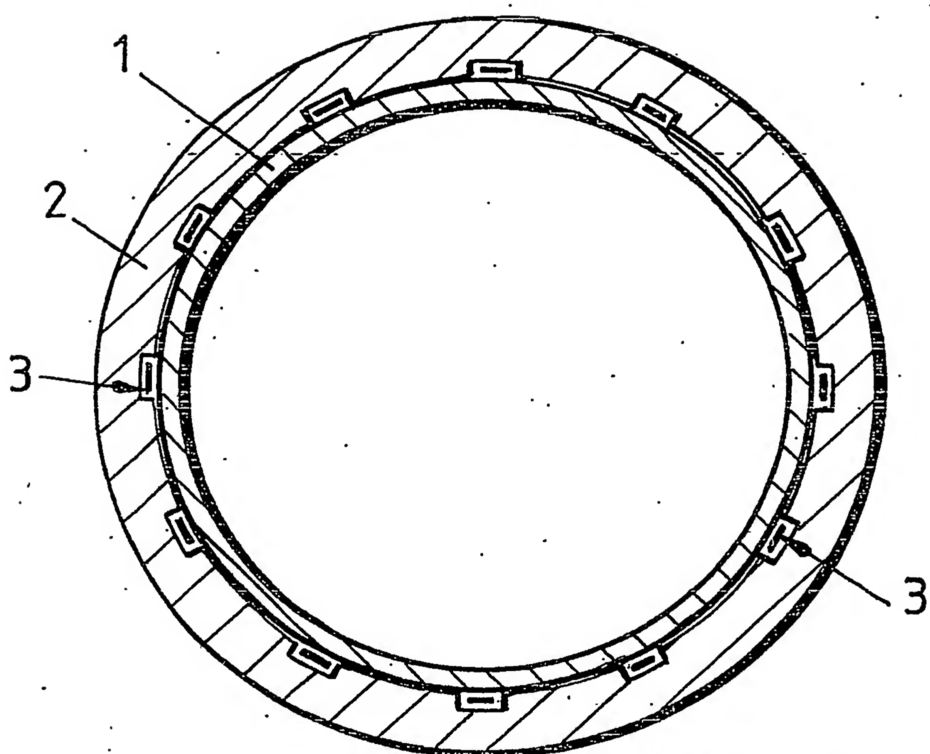

FIG.1

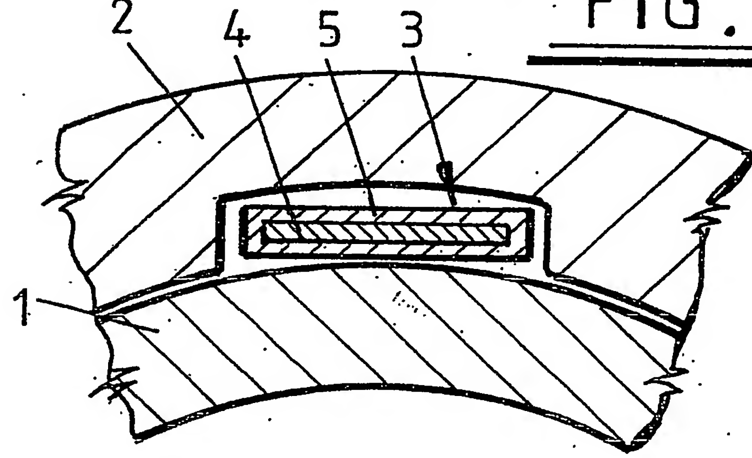

FIG.2

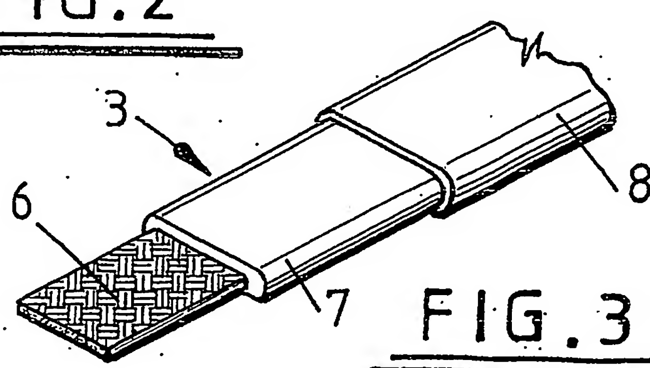

FIG.3